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# A study of the relationship of certain innate capacities to success in football

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# A STUDY OF THE RELATIONSHIP OF CERTAIN INNATE CAPACITIES TO SUCCESS IN FOOTBALL

Submitted by

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# CHAPTER I

## INTRODUCTION AND PURPOSE

Statement of the problem.-- This is a study of the relationship of the innate capacities of reaction time, visual span of apprehension and depth perception to success in football.

Introduction.-- The present method or procedure by which a coach of a football team selects and places personnel is for the most part a subjective estimate leading to the trial and error system. This method is frequently not possible for a number of weeks or months after the beginning of the school year. Prognosis, or prediction of as-yet-undeveloped and still latent abilities, and also the diagnosis of the performance disabilities are by necessity subjective and a trial and error procedure based upon the experience of the coach.

The degree to which a candidate approaches or reaches a high standard of measure or performance in the five S's -- Speed, Skill, Savvy, Spirit and Size -- has for the most part constituted a coach's method of evaluating new candidates and predicting their performance in football. College coaches may have advance information on the achievement of the candidates in some, or possibly all of these attributes. However, the high school coach has no previous record or advance information of the boy's capacities upon which to base his estimates.

coach. There must be a great deal wrong with subjective selection and with consensus composite ratings by coaching staffs.

This method of evaluation is criticized by Symonds,[1] "Many investigators have noted the tendency for general impressions to spread to specific traits, to which tendency Thorndike has given the name 'halo effect'".

Wells[2] states, "There is a possibility of one rather disturbing constant error in measures of this nature whose extent it is never possible to know accurately. There is noted introspectively a tendency to grade for general merit at the same time as for the qualities, and to allow an individual's general position to influence his position in the qualities".

Does an athlete have a faster reaction time than a non-athlete? How does the depth perception of an athlete compare with that of a non-athlete? Is there a difference in the span of apprehension of athletes and non-athletes? Must a forward passer have faster reaction time or better span of visual apprehension than a lineman? Is good span an instrumental factor in enabling a boy to be elusive in a broken field? Does depth perception enter into the effectiveness of a boy's blocking downfield or along the line?

If there was a definitely known relationship between some innate capacity or combination of innate capacities and performance, would not this relationship help in deciding the probability of future success in

1/P. M. Symonds, Diagnosing Personality and Conduct, p. 111. 1931.

2/F. L. Wells, "Statistical Study of Literary Merit", Archives of Psychology, No. 7, 1907, p. 21.

actual performance, or in diagnosing the cause of a breakdown in performance?

The results of this study might enable one to draw better conclusions, at least as far as the innate capacities tested are concerned, and aid one in the football coaching profession to serve one's players better and improve the football program.

# CHAPTER II

## SURVEY AND ANALYSIS OF THE LITERATURE

Literature concerning reaction time.-- Reaction time is the interval elapsing before a predetermined movement follows a predetermined stimulus.

Cottell[1/] emphasizes that the length of reaction time is not greatly affected by the condition of the observer, the time of day, the number of reactions already made, nor the amount of practice. The reaction time is about 0.025 second longer for light than for sound.

The whole scientific problem of reaction time as a field for careful investigation grew out of observations by astronomers who noted differences among themselves in recording the moment when the image of a star reached the cross hands of an optical instrument. The astronomical period began in 1850 when Helmholtz published the first simple reaction time to measurement to Electric Stimulation and extended to 1874 when Wundt published "Grundziige der Physiologichen Psychologie". Physiological periods dated from 1865 with Publication of Donders and de Jaagai's experiments on times of discrimination and choice.

1/J. M. Cottell and Charles S. Dolley, "On Reaction Times and Velocity of the Nervous Impulse", Memoirs of the National Academy of Science, Vol. VII, Government Printing Office, Washington, D. C., 1895, pp. 393-415.

The following were the successive stages of psychology period of major interest:

1. Time relations of simple and complex mental processes and the variations with the quality, extensity, and complexity of stimuli (1865 - 1868).
2. The effect of direction of attention upon reaction times (1888 - 1905).
3. Introspective analysis of the reactions (1905 - 1912) 1/

The two most prominent contributors to the field of reaction-time have been Wundt with his theory of apperception in reaction-time and Cottell with his reflex theory.

Although athletics had literally been playing with these speed factors for many centuries, it generally happened that other factors such as training, motivation, effort, spirit and attitudes occupied the surface position. Such native factors as physical build were recognized as necessary qualities in contact games, innate capacities such as reaction time came to be considered but slowly.

Experiments have been performed with the college athlete to determine the relation between reaction time and his ability to perform as an athlete. There has probably been very little work done on reaction time in relation to ability to play football, with reference to the high school boy. College coaches stress the importance of fast reaction but acknowledge the lack of research in this field and admit

1/V. A. C. Henmon, "Professor Cottell's Work in Reaction Time", Archives of Psychology, No. 30, April, 1914, pp. 20-27.

to subjective procedure.

Miles and Graves have been interested in the reaction time of college football men. They have discovered that there is a very close relation between the players' football charging ability and their value as football players. Miles states: (1) "We therefore conclude that the football charge when it occurs as a response to a signal, the exact timing of which cannot be guessed by the players, requires about 0.4 seconds as a average." He also says: (2) "It appears certain that the coaches who made these rankings were firm in the conviction that speed is a fundamental condition for efficiency in football players." And Miles goes on to say: (3) "They point to the conclusion that speed is important but that first of all it is wise to discover who has the speed and in what degree."1/

Snygg in his study of reaction time and its relationship to the ability to play football, sent a number of coaches a request for written statements answering the following question: "Is speed based upon reaction time a vital factor in football?"2/

Coach A. N. McMillin wrote the following statement:

> "In my opinion, speed, based upon reaction time, is one of the most important factors in the development of football players who are to become finished performers. We have no valid or reliable test to measure this speed but are forced to use subjective judgment in doing this phase of the work....There is a great deal to be done in this field."3/

1/W. R. Miles, "Individual and Group Reaction-Time in Football Charging", Research Quarterly, Vol. 2, No. III, October, 1931.

2/R. E. Snygg, "The Relationship Between Motor Reaction Time and Ability to Play Football", University of Omaha, 1937.

3/Ibid., p. 3.

Coach B. W. Bierman wrote: "Speed and fast reaction time naturally are two of the most vital factors in football. So many things in football might be classed as 'emergencies' and reaction time largely determines whether this 'emergency' can be properly met."[1/]

Glenn S. Warner wrote: "Speed and quick starting are two of the main requisites of a good football player, quick reaction to starting signals or getting off with the snap of the ball are vital to the success of any team whether on the offense or defense, but especially on the offense."[2/]

Coach Andrew Kerr wrote: "I have made no experiments on the reaction time of football men that you may use in your study. You may quote me, however, as saying that it is my opinion that speed based upon reaction time is a vital factor in football."[3/]

Coach Francis Schmidt wrote as follows: "Speed of reaction is probably the most valuable single asset a player can have, <u>especially a back</u>."[4/]

Coach Lynn Waldorf wrote:

> "Speed is perhaps the most important single element in the game of football....A team whose members start fast, get to the point of attack quickly, rather than track speed like a one hundred yard sprinter, will usually be far more successful in its game than a slow team. By speed in this connection is meant ability of a back, for instance, to start rapidly in any direction the instant the ball is snapped and the ability of

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1/*Ibid*., p. 3.

2/Snygg, *op. cit*., p. 3.

3/Snygg, *op. cit*., p. 3.

4/Snygg, *op. cit*., p. 4.

a lineman to react quickly and get across the neutral zone before his opponent. Speed, of course, in this sense is intimately connected with coordination."1/

Snygg used the Marietta Reaction Time Set Machine in his experiment and concluded that a fast reaction time does not necessarily indicate a good football player. This opinion is contrary to that held by many leading coaches. He also concludes that it is difficult to pick high school players by using only the reaction time results; but that a reaction time test does show a coach his fastest reacting men, thus making it possible to apply this knowledge to predicting performance and selecting players for particular positions.2/

Slater-Hammel and Stumpner in a study to attain some estimate of the maximal limits of batting reaction-time were concerned with choice batting reaction-time, as an actual batting situation probably involves choice reactions. They found that a batter must obtain information as to where the ball will be as it passes over home base before the ball reaches the midpoint of its flight. After the ball has passed this point, there would no longer be time for a batter to react to any changes in the ball's direction of flight.3/ Some years ago when Babe Ruth was tested at the psychological laboratories of Columbia University, it was found that the Bambino's reaction time was twice as fast as the average. Obviously, this is a tremendous advantage when facing a pitcher, for it enables him to wait and study

1/Snygg, op. cit., p. 4

2/Snygg, op. cit., pp. 33-34.

3/Slater-Hammel and R. L. Stumpner, "Choice Batting Reaction-Time", Research Quarterly, Vol. 22, October, 1951.

the ball longer before starting his swing.[1]

Burpee and Stroll, using the Atwood Machine type instrument found fast, small-muscle reaction time appears to be an important factor in obtaining marked success in physical education activities.[2]

In a study to attempt to discover the extent of variation of reaction time as based upon the ability to move the hand in response to the stimulus of a bell at different hours throughout the day, Elbel concluded that two periods throughout the day high mean scores are reached, one in the morning and one in the afternoon. The maximum speed is reached in the afternoon.[3]

Miles and Graves observed that Rockne's[4] criticism of the visual signal (watching the ball) in football charging seemed very much in point and conformed absolutely to the large amount of reaction time data that has been accumulated in psychological laboratories, where it has characteristically been found that the shortest reaction time occurs for auditory signals. Response to visual signals is often 0.04 seconds slower.[5]

1/Burpee and Stroll, "Measuring Reaction Time of Athletes", Research Quarterly, Vol. 7, March, 1936.

2/Ibid.

3/E. R. Elbel, Ph.D., "A Study in Variation in Response Time", Research Quarterly, Vol. 10, March, 1939.

4/Knute Rockne, Coaching, The Devin-Adair Co., New York, 1925, pp. 168-169.

5/W. R. Miles and B. C. Graves, "Effect of Signal Variation on Football Charging", Research Quarterly, Vol. 2, October 1931, pp. 1-5.

Atweel and Elbel [1] found that there was a slight difference between hand reaction response time for a 14-17 age high school group with tendency for more rapid response with increase in age. The difference between age groups was not statistically significant. A slight difference also existed between means for each of the high school groups.

Goldfarb [2] found that men tend to be reliably faster than women in both simple and discriminatory time of reaction. Among the men there is a tendency to decline from the younger to the older age groups in speed of simple and discriminatory reaction.

Keller found that there is a positive relationship between the ability to move the body quickly and success in athletic activities. He also concluded that the requirements of bodily movement are not the same for all sports. A person with relatively slow total body reaction time has a better chance of attaining success in more individual activities such as swimming, gymnastics and wrestling than in those sports in which he is required to react to rapidly changing conditions and to the movements of several team mates and opponents as is found in football, basketball, baseball and the like. Men who are not quick enough to achieve proficiency and success in those highly competitive gamesmight be guided into the more individual type of sport

1/W. O. Atweel and E. R. Elbel, "Reaction Time in Male High School Students in 14-17 Age Group", Research Quarterly, Vol. 19, March, 1948.

2/W. Goldfarb, Ph.D., "An Investigation of Reaction Time in Older Adults", Bureau of Publications, Teachers College, Columbia University, New York, 1941.

and possibly become outstanding performers.[1]

Visual span of apprehension.-- An individual's span of apprehension is the number of objects which can be apprehended or grasped in a single fixation.

Woodworth[2] explains that:

> "The material to be grasped consist simply of objects of the same kind such as oranges lying on a table. You look at them and say there are a 'great many' or 'several' or 'just a few'. A method was devised long ago for obtaining the exact number by counting, but we wish to find out how well one can do, without counting, by taking a single glance with attention directed to the number of objects."

The most agreed upon fact concerning span is that it is not a span of attention but should be called a span of apprehension. Actually we are measuring a span of apprehension and report -- because you cannot be given credit for having seen a number of items unless you can report them.

Saltzman in 1948 found that the use of reaction-time was a better method of measuring span than tachistoscope methods. He asserts very definitely that any change in the span is an artifact of the method of measurement.[3]

Eames utilized a tachistoscope to measure speed of word recognition and concluded that, (1) reading is accomplished through the recognition

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1/L. F. Keller, Ph.D., "The Relation of Quickness of Bodily Movement to Success in Athletics", Research Quarterly, Vol. 13, May, 1942.

2/R. S. Woodworth, Experimental Psychology, Henry Holt & Co., New York, 1938, pp. 670-680.

3/J. Saltzman and W. R. Garner, "Reaction Time as a Measure of Span of Attention", Journal of Psychology, 25:227-241, 1948.

of minimal clues, (2) the speed of word recognition can be measured and an accurate estimate of progress made, (3) there appears to be some correspondence between increments in the speed of word recognition and increments in the horizontal diameter of the visual field and speed of recognition.[1/]

Span experiments have been used in the studies of eye fixations and reading ability.[2/]

In 1921 Fernberger advanced the idea that the statistical limen, that stimulus-value for which correct judgments are given 50 per cent of the time, is the most reliable measure of range of visual apprehension.[3/] Later studies have not followed this reasoning, however, and usually report an observation completely wrong when it is not completely right.

Whipple[4/] in his studies of the effect of practice upon the range of visual attention and visual apprehension showed that "individual differences are so striking and so specific as to negate the motion of a general ability to apprehend visually". The effect of practice, as before, is negligible when adaptation and assimilative devices are eliminated. A qualitative analysis shows that performance

1/Thomas H. Eames, "A Study of the Speed of Word Recognition", Journal of Educational Research, Vol. 31, 1937-38, pp. 181-187.

2/C. A. Knehr, "The Effects of Monocular Vision on Measures of Reading Efficiency and Perceptual Span", Journal of Experimental Psychology, 29:133-154, 1941.

3/L. W. Fernberger, "A Preliminary Study of the Range of Visual Apprehension", 39 :121-123, 1921. American Journal of Psychology.

4/G. M. Whipple, "The Effect of Practice Upon the Range of Visual Attention and of Visual Apprehension", Journal of Educational Psychology, May, 1910, pp. 249-262.

is conditioned by numerous factors of which the most important are: native capacity, degree of attention, specific capacity for given types of material, ease of assimilation of the material shown, "obstruction" or distraction, ideational type, voluntary restriction of observation and grouping.

Whipple states that practice is negative, yet Miss Aiken 1/ in an account published in 1896 concerns her exercises with improvement of visual span.

In connection with the effect of practice in improvement of visual span, it might be best to practice or improve visual span or comprehension according to the individual need and ability. Neither Whipple's nor Miss Aiken's facts negate the idea of general ability in visual apprehension. We may say only that a given individual excels in the attentive observation of pictures, drawings, words, or certain kinds of objects, not that he excels in all-round observation.

Bills 2/ found that with very short exposure time only five separate items could be apprehended, but if the items were arranged in patterns or combined in a meaningful whole, the span of apprehension was much greater.

Depth perception.-- Depth perception is defined as the ability to appreciate or discriminate the third dimension or to judge distance, and to orient oneself in relation to other objects within the visual

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1/*Ibid.*, p. 259.

2/A. G. Bills, General Experimental Psychology, Longmons, Green & Co., New York, 1934.

field.

Leonardo da Vinci [1] found that depth perception was revealed largely by light and shadow. He found that the relative distance of objects in the field of view is revealed mostly by perspective, of which he distinguished three kinds: (1) linear perspective, the diminition of angular size with increased distance; (2) detail perspective, the loss in the distance of the finer lines, angles, shape and shading of an object; (3) aerial perspective, the partial loss of an object color from the effect of the air, fog, or smoke through which the distant object is seen.

Millis [2] found that testing depth perception of prospective pilots was an aid in selecting fighter pilots.

Loy [3] believes that the value of peripheral vision in depth perception is shown by adding a third rod as a fixation point against the back board of the Howard-Dolman apparatus.

Scott and Sumner [4] in experiments using the Howard and Dolman depth perception apparatus discovered that it appeared necessary to take into consideration the eyedness of one's subjects either by

1/Robert S. Woodworth, op. cit., pp. 651-652.

2/A. E. Millis, "Depth Perception as an Aid to Selecting Fighter Pilots", Journal of Aviation Medicine, Vol. 15, 1944, pp. 328-329.

3/A. W. Loy, "The Value of Peripheral Vision in Depth Perception as Applied to Aviation", Naval Medical Bulletin, Vol. 28, 1930, pp. 13-18.

4/R. B. Scott and F. C. Sumner, "Eyedness as Affecting Results Obtained with the Howard-Dolman Depth Perception Apparatus", Journal of Psychology, Vol. 27, April, 1949, pp. 29-30.

matching subjects for eyedness or else by subjects. Right eyed subjects are far more common than left eyed ones.

Baird [1/] in his investigation showed that under experimental conditions which exclude all known criteria of depth -- save only accommodation and convergence -- it still is possible to perceive changes of distance. This establishes the fact that either accommodation or convergence, or both, contribute to the perception of depth.

Kiilpe [2/] found that the most important aid to the estimation of depth was the difference between the retinal images of the two eyes. He found that the right eye sees a depth difference of two points in space differently from the left eye. This can be verified by observation (alternate closing of the two eyes) and geometrical construction.

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1/J. W. Baird, "The Influence of Accommodation and Convergence Upon the Perception of Depth Perception", American Journal of Psychology, Vol. 14, January, 1903, pp. 150-160.

2/Oswald Kiilpe, Outlines of Psychology, Swan Sonnenscheim and Co., London, MacMillan and Co., New York, 1945, pp. 357-361.

## CHAPTER III

## TECHNIQUES AND PROCEDURES

I. Subjects Used.

A. As subjects for this study, 44 boys from Waltham High School were used. Twenty-two of these boys were 1950 football lettermen and 22 were boys who had never taken part in, or reported for any varsity athletic team in high school. The football group could be classified as successful since they were a component part of a squad that had a two-year record of 18 wins and 2 losses in 1949 and 1950. The non-athletic group was carefully selected as to age, weight, and height. (Table I)

B. The visual span test was administered to a group of five or six simultaneously. The reaction time and depth perception tests were administered individually. A group of this number was tested in all three capacities in approximately 90 minutes.

II. Reaction Time.

A. Instrument: Stoelting Visual Reaction Timer.

1. Consisted of a controlled cabinet.

a. A timing clock or chronoscope which can be read to 0.003 seconds.

b. The controls were a three-point selection switch key and a three-position switch key for indicating color at the light source.

2. Reaction key board.

a. Three telegraph type keys agree with the point selection switch key.

b. The reaction key board and light stimulus were fastened to a three quarter inch base to prevent movement and to standardize procedure.

3. Light Stimulus.

a. Three colored lights each controlled individually by the three-position visual switch.

4. Starting board.

    a. Consisted of a 4 by 13 inch board, three quarter inch thick put there to raise the hand up to approximate level of the response keys and it also standardized the distance of subject's hand from keys.

5. Plywood shield.

    a. Shielded the subject's view of the control cabinet and operator's hands.

B. Test.

1. Simple (one response to stimulus).

    a. Subject sat at the table which held keyboard and light stimulus with hand resting on starting board and arm resting on table. The middle finger was placed in position marked "start" and the heel of the hand touched the starting board.

    b. Subject was given six practice trials. On presentation of red stimulus the subject moved his hand forward a distance of $1\frac{1}{2}$ inches and depressed key Number 2 directly in front of hand. This stopped the chronoscope and time lapses from the time light was stimulated and the time was recorded. The subject's hand reaction returned to "start" position after each response.

    c. After the practice trials, which were not recorded, eleven reaction time trials were recorded for use in this study.

    d. The subject was given a ready signal by verbal command "ready".1/ A fore-period from two to four seconds followed the ready signal before stimulus was presented.2/ A random variation of the length of the fore-period was set up by the operator. The same order was used for each subject.

1/R. S. Woodworth, *op. cit.*, p. 314.

2/*Ibid.*, p. 315.

2. Choice or Disjunctive[1] Reaction.

   a. Subject sat same as above with the same starting position.

   b. Six practice trials were given.

   c. Subject had choice of movement. On presentation of amber stimulus subject moved hand diagonally and to the left to depress key three inches away. On presentation of green stimulus subject moved hand diagonally to the right to depress key three inches away.

   d. A ready signal and varied fore-period was used as in simple reaction time.

   e. Eleven readings were taken on this test. Five readings on amber and six readings on green.

3. Discriminatory reaction time.

   a. Subject had to discriminate between the red, green, and amber stimuli.

   b. Starting position was the same as for the two other tests.

   c. Four amber, three red, and four green made up the eleven readings for this test.

III. Depth Perception Test.

A. Instrument: Howard-Dolman Depth Perception Apparatus.

1. Lighting.

   a. A 75-watt non-glare bulb in line with front of box and two feet above.

   b. A 75-watt non-glare bulb one foot back from front and two feet above the instrument.

   c. The anterior and posterior walls were painted white.

1/*Ibid.*, p. 331.

2. Berrens [1] description of apparatus and the test procedure.

   a. The apparatus consisted of two vertical rods, one of which was fixed and one was movable on a track. Through the window of the apparatus these rods were observed by the subject seated at a distance of 20 feet.

   b. Two strings attached to the movable rod were placed in the subject's hands, and he was directed to move the rod by means of the strings until it appeared to lie in the same plane as the fixed rod. He then dropped the strings. From a scale on the apparatus the readings of ten successive attempts were recorded in millimeters.

3. Scoring technique.

   a. Weymouth and Hirsch [2] found a reliability of 0.86 if the following technique was used:

$$D = \sqrt{\frac{\Sigma X^2}{10}}$$

IV. Span of Apprehension.

A. Instrument: Tachistoscope Delineascope Projector. [2]

1. Construction of instrument.

   a. Instrument was made up of one Spencer Delineascope Projector model M. S. with a number four Betax Wollensak shutter. This shutter was mounted on the projector.

B. Test.

1. Preparations made for testing.

1/Conrad Berens, and Joshua Zukerman, Diagnostic Examination of the Eyes, Lippnosti Publishers, 1946, p. 578.

2/F. Weymouth and M. Hirsch, "Reliability of Certain Tests for Determining Distance Discrimination", American Journal of Psychology, Vol. 58, 1945, pp. 379-390.

a. Fifty 2 by 2 slides were used.

b. Five sets of ten 5 by 5 cards (white) with haphazardly arranged dots (one quarter inch dots). The number of dots ranged from four to thirteen.

c. Cards were photographed on negative film.

d. Negatives were transposed to positive films so dots appeared black when projected. Slides were made from the positive films.

e. The Tachistoscope was set 12 feet from the screen.

2. Procedure of tests.

a. Subjects taking tests sat 20 feet from the screen.

b. Six subjects took the tests at one time.

c. The test was explained to the subjects.

d. A verbal "ready" signal and a fore-period of two seconds were used before each slide was presented on the screen.

e. The length of the exposure was five tenths of a second.

f. Pre-exposure field and post-exposure field controlled by a 75-watt non-glare bulb two feet behind and eight feet above subjects.

g. Fixation point on middle of 48 inch by 48 inch screen consisted of a small x marked with scotch tape.

h. Subjects were asked to write down the number of dots they thought were presented on each trial on score sheet. The 50 slides were arranged at random and shown on the screen. Then the test was presented again with each slide turned 90 degrees to the right in a different order. This was done to insure against practice. This was repeated until each slide was presented four times. Each time with the slide in a different position and in a different order. After the presentation of each 50, there was a two minute pause.

3. Scoring technique.

   The scoring technique used was the method suggested by S. W. Fernberger.1/

   a. On a score card in the first column the number of stimulus objects beginning with four and ending with thirteen were listed.

   b. In the second column the number of slides correct in each category were listed.

   c. The items in column one were multiplied by the items in column two.

   d. In column three the scores were added for the test scores.

   e. The above method did not determine an individual's range of apprehension but did give it a test score which could be used to compare the two groups tested and as a score in obtaining the level of significance.

1/S. W. Fernberger, "Study of the Range of Visual Apprehension", American Journal of Psychology, Vol. 32, 1921, pp. 121-133.

Table 1. Age, Weights and Heights -- Football and Non-Athletics

| | Age | | Weight | | Height (inches) | |
|---|---|---|---|---|---|---|
| Case No. | Football | Non-Athletic | Football | Non-Athletic | Football | Non-Athletic |
| 1 | 17 | 18 | 187 | 162 | 70 | 70 |
| 2 | 18 | 15 | 180 | 135 | 71 | 67 |
| 3 | 17 | 15 | 155 | 138 | 67 | 66 |
| 4 | 17 | 18 | 145 | 195 | 66 | 71 |
| 5 | 17 | 18 | 160 | 145 | 69 | 72 |
| 6 | 16 | 18 | 148 | 160 | 72 | 72 |
| 7 | 17 | 15 | 140 | 160 | 66 | 74 |
| 8 | 17 | 16 | 170 | 130 | 69 | 70 |
| 9 | 17 | 18 | 150 | 170 | 68 | 70 |
| 10 | 15 | 17 | 170 | 176 | 75 | 68 |
| 11 | 18 | 17 | 160 | 140 | 67 | 67 |
| 12 | 16 | 17 | 143 | 153 | 70 | 68 |
| 13 | 16 | 17 | 155 | 155 | 70 | 66 |
| 14 | 19 | 18 | 147 | 165 | 68 | 69 |
| 15 | 18 | 17 | 195 | 188 | 72 | 70 |
| 16 | 16 | 17 | 175 | 165 | 70 | 71 |
| 17 | 15 | 16 | 148 | 173 | 70 | 70 |
| 18 | 17 | 19 | 163 | 156 | 70 | 68 |
| 19 | 17 | 15 | 135 | 142 | 66 | 67 |
| 20 | 17 | 17 | 150 | 163 | 72 | 71 |
| 21 | 19 | 18 | 154 | 206 | 70 | 71 |
| 22 | 18 | 15 | 170 | 137 | 72 | 67 |
| Totals | 374 | 371 | 3500 | 3514 | 1530 | 1525 |
| Mean | 17 | 16.9 | 159 | 159 | 69.5 | 69 |

Table 2. Reaction Time Median Scores -- Football and Non-Athletic

| Case No. | Simple Reaction Time | | Choice Reaction Time | | Discriminatory Reaction Time | |
|---|---|---|---|---|---|---|
| | Football | Non-Athletic | Football | Non-Athletic | Football | Non-Athletic |
| 1 | 350 | 330 | 410 | 510 | 515 | 520 |
| 2 | 320 | 325 | 480 | 510 | 515 | 490 |
| 3 | 260 | 305 | 525 | 410 | 520 | 550 |
| 4 | 255 | 405 | 330 | 560 | 500 | 560 |
| 5 | 310 | 320 | 460 | 465 | 560 | 450 |
| 6 | 275 | 325 | 370 | 530 | 500 | 490 |
| 7 | 290 | 315 | 490 | 520 | 520 | 485 |
| 8 | 370 | 305 | 530 | 480 | 610 | 535 |
| 9 | 290 | 365 | 460 | 500 | 505 | 615 |
| 10 | 360 | 350 | 480 | 565 | 560 | 570 |
| 11 | 260 | 305 | 405 | 480 | 440 | 555 |
| 12 | 325 | 360 | 440 | 530 | 545 | 560 |
| 13 | 305 | 315 | 435 | 470 | 555 | 595 |
| 14 | 290 | 360 | 470 | 515 | 500 | 650 |
| 15 | 300 | 340 | 420 | 400 | 485 | 450 |
| 16 | 300 | 280 | 480 | 485 | 475 | 510 |
| 17 | 375 | 360 | 535 | 495 | 470 | 600 |
| 18 | 320 | 305 | 505 | 440 | 545 | 495 |
| 19 | 350 | 330 | 560 | 425 | 595 | 465 |
| 20 | 280 | 315 | 370 | 510 | 480 | 575 |
| 21 | 255 | 280 | 340 | 360 | 465 | 430 |
| 22 | 325 | 310 | 440 | 450 | 480 | 540 |
| Totals | 6765 | 7205 | 10015 | 10610 | 11340 | 11690 |
| Mean | 308 | 328 | 455 | 482 | 515 | 531 |
| S. D. | 36.08 | 29.1 | 61.39 | 50.5 | 41.99 | 56.9 |

Table 3. Reaction Time Median Scores -- Backs and Linemen

| Simple Reaction Time | | | | Choice Reaction Time | | Discriminatory Reaction Time | |
|---|---|---|---|---|---|---|---|
| Case No. | Backs | Case No. | Linemen | Backs | Linemen | Backs | Linemen |
| 3 | 260 | 1 | 350 | 525 | 490 | 520 | 515 |
| 4 | 255 | 2 | 320 | 330 | 480 | 400 | 515 |
| 5 | 310 | 8 | 370 | 460 | 530 | 560 | 610 |
| 6 | 275 | 10 | 360 | 370 | 480 | 500 | 560 |
| 7 | 290 | 12 | 325 | 490 | 444 | 520 | 545 |
| 9 | 290 | 13 | 305 | 460 | 435 | 505 | 555 |
| 11 | 260 | 15 | 300 | 405 | 420 | 440 | 485 |
| 14 | 290 | 17 | 375 | 470 | 535 | 500 | 470 |
| 16 | 300 | 18 | 320 | 480 | 505 | 475 | 545 |
| 19 | 350 | 20 | 280 | 560 | 370 | 595 | 480 |
| 21 | 255 | 22 | 325 | 340 | 440 | 465 | 480 |
| Totals | 3135 | | 3630 | 4890 | 5125 | 5480 | 5760 |
| Mean | 285 | | 330 | 445 | 466 | 498 | 524 |
| S. D. | 27.46 | | 28.9 | 70.9 | 47.66 | 51.2 | 41.5 |

Table 4. Depth Perception and Visual Span of Apprehension Test Scores — Football and Non-Athletic

| | Depth Perception | | Visual Span of Apprehension | |
|---|---|---|---|---|
| Case No. | Football | Non-Athletic | Football | Non-Athletic |
| 1 | 20.5 | 20.9 | 597 | 453 |
| 2 | 19.4 | 11.7 | 751 | 627 |
| 3 | 18.7 | 63.4 | 558 | 790 |
| 4 | 10.8 | 44.5 | 893 | 534 |
| 5 | 11.3 | 9.0 | 506 | 627 |
| 6 | 11.1 | 22.7 | 232 | 662 |
| 7 | 16.3 | 10.4 | 319 | 609 |
| 8 | 30.8 | 42.1 | 622 | 675 |
| 9 | 27.4 | 15.4 | 662 | 850 |
| 10 | 15.2 | 19.8 | 605 | 610 |
| 11 | 5.9 | 27.7 | 673 | 509 |
| 12 | 34.9 | 24.3 | 634 | 361 |
| 13 | 24.2 | 15.1 | 393 | 539 |
| 14 | 5.6 | 32.6 | 703 | 527 |
| 15 | 6.3 | 14.3 | 769 | 375 |
| 16 | 12.1 | 18.2 | 691 | 560 |
| 17 | 22.8 | 11.8 | 956 | 710 |
| 18 | 15.8 | 8.9 | 566 | 666 |
| 19 | 30.9 | 27.2 | 768 | 489 |
| 20 | 11.4 | 7.4 | 667 | 774 |
| 21 | 7.3 | 9.8 | 865 | 612 |
| 22 | 13.3 | 9.2 | 610 | 434 |
| Totals | 372.0 | 466.4 | 13940 | 12993 |
| Mean | 16.9 | 21.2 | 634 | 590 |
| S. D. | 12.5 | 20.4 | 170.9 | 109.8 |

Table 5. Depth Perception and Visual Span of Apprehension Test Scores -- Backs and Linemen

| Depth Perception | | | | Visual Span of Apprehension | | | |
|---|---|---|---|---|---|---|---|
| Case No. | Backs | Case No. | Linemen | Case No. | Backs | Case No. | Linemen |
| 3 | 18.7 | 1 | 20.5 | 3 | 558 | 1 | 597 |
| 4 | 10.8 | 2 | 19.4 | 4 | 873 | 2 | 751 |
| 5 | 11.3 | 8 | 30.8 | 5 | 506 | 8 | 622 |
| 6 | 11.1 | 10 | 15.2 | 6 | 232 | 10 | 605 |
| 7 | 16.3 | 12 | 34.9 | 7 | 319 | 12 | 634 |
| 9 | 27.4 | 13 | 24.2 | 9 | 662 | 13 | 393 |
| 11 | 5.9 | 15 | 6.3 | 11 | 673 | 15 | 769 |
| 14 | 5.6 | 17 | 22.8 | 14 | 703 | 17 | 956 |
| 16 | 12.1 | 18 | 15.8 | 16 | 691 | 18 | 566 |
| 19 | 30.9 | 20 | 11.4 | 19 | 768 | 20 | 667 |
| 21 | 7.3 | 22 | 13.3 | 21 | 865 | 22 | 610 |
| Totals | 157.4 | | 214.6 | | 6870 | | 7170 |
| Mean | 14.3 | | 19.5 | | 625 | | 651 |
| S. D. | 7.9 | | 8.0 | | 169.3 | | 137.2 |

# CHAPTER IV

## TREATMENT AND ANALYSIS OF THE DATA

To compute the level of significance between the two groups tested the following formulas were used:

1. Standard Deviation. 1/

$$S.D. = \sqrt{\frac{\Sigma x^2}{N}}$$

2. Standard Error of Mean. 2/

$$\sigma_M = \frac{\sigma\,(sample)}{\sqrt{N-1}}$$

3. Standard Error of Difference of Means. 3/

$$\sigma(M_1 - M_2) = \sqrt{\sigma_{M_1}{}^2 + \sigma_{M_2}{}^2}$$

4. Critical Ratio. 4/

$$\frac{M_1 - M_2}{\sigma(M_1 - M_2)} = t$$

t = level of significance

1/E. F. Lindquist, A First Course in Statistics, Houghton Mifflin Company, Boston, 1942.

2/Ibid., p. 75.

3/Ibid., p. 120.

4/Ibid., p. 130.

Table 6. Level of Significance (t) of Tests -- Football and Non-Athletic

| Group Tested | No. Tested | Mean | Standard Deviation | Standard Error of Mean | Standard Error of Difference of Mean | Difference of Mean | Critical Ratio | (t) Level of Significance |
|---|---|---|---|---|---|---|---|---|
| | | | | Simple Reaction | | | | |
| Football<br>Non-Athletic | 22<br>22 | 308<br>328 | 36.08<br>29.1 | 7.87<br>6.35 | 10.1 | 20 | 1.98 | Significant at 20% Level |
| | | | | Choice Reaction | | | | |
| Football<br>Non-Athletic | 22<br>22 | 455<br>482 | 61.39<br>50.5 | 13.4<br>11.02 | 17.35 | 27 | 1.56 | Significant at 20% Level |
| | | | | Discriminatory Reaction | | | | |
| Football<br>Non-Athletic | 22<br>22 | 515<br>531 | 41.99<br>56.9 | 9.16<br>12.14 | 15.4 | 16 | 1.04 | Not Significant |
| | | | | Visual Span of Apprehension | | | | |
| Football<br>Non-Athletic | 22<br>22 | 634<br>590 | 170.9<br>109.8 | 37.31<br>23.97 | 54.4 | 44 | .80 | Not Significant |
| | | | | Depth Perception | | | | |
| Football<br>Non-Athletic | 22<br>22 | 16.9<br>21.2 | 12.5<br>20.4 | 2.72<br>4.45 | 5.22 | 4.3 | .82 | Not Significant |

Table 7. Level of Significance (t) of Tests -- Backs and Linemen

| Group Tested | No. Tested | Mean | Standard Deviation | Standard Error of Mean | Standard Error of Difference of Mean | Difference of Mean | Critical Ratio | (t) Level of Significance |
|---|---|---|---|---|---|---|---|---|
| | | | | Simple Reaction | | | | |
| Backs | 11 | 285 | 27.46 | 8.68 | 12.6 | 45 | 3.57 | Significant at 1% Level |
| Linemen | 11 | 330 | 28.9 | 9.14 | | | | |
| | | | | Choice Reaction | | | | |
| Backs | 11 | 445 | 70.9 | 22.43 | 27.02 | 21 | .77 | Not Significant |
| Linemen | 11 | 466 | 47.66 | 15.08 | | | | |
| | | | | Discriminatory Reaction | | | | |
| Backs | 11 | 498 | 51.2 | 16.07 | 20.71 | 26 | 1.25 | Not Significant |
| Linemen | 11 | 524 | 41.5 | 13.13 | | | | |
| | | | | Visual Span of Apprehension | | | | |
| Backs | 11 | 625 | 169.3 | 53.57 | 69.5 | 18 | .26 | Not Significant |
| Linemen | 11 | 651 | 137.2 | 43.89 | | | | |
| | | | | Depth Perception | | | | |
| Backs | 11 | 14.3 | 7.9 | 2.5 | 3.55 | 5.2 | 1.46 | Significant at 20% Level |
| Linemen | 11 | 19.5 | 8.0 | 2.53 | | | | |

Procedure.-- The level of significance established in this study was interpreted from Fisher's table [1/] of "minimum values of significance ratio required for significance at various levels".

The "critical value" of the significance ratio as determined from the table is 1.32 for the 20 per cent level of confidence, and 2.08, 2.53, 2.83 and 3.81 for the 5 per cent, 2 per cent, 1 per cent and 0.1 per cent levels respectively.

Any level of significance of 2 per cent or less would be established as "very significant", i.e. that we are highly confident (or "practically certain") that the two samples differ in the trait measured.

Any level of significance more than 2 per cent would be established by the "null" hypothesis (the hypothesis that the true difference is zero). We would establish this by rejecting the "null" hypothesis at a low level of confidence, i.e. rejecting at the 20 per cent level or 5 per cent level, etc.

The more recent practice is to utilize the 1 per cent or 2 per cent levels as "critical" values of the significant ratio.

Fisher's table enables computation for any size sample by utilizing the "Degrees of Freedom" (N-1) in establishing the values of significance.

Analysis of Data.-- The following statements concern only the data in this study:

1/E. F. Lindquist, op. cit., p. 240, Table 3.

The hypothesis that the true difference between groups tested in a certain innate capacity is zero can be rejected at the following levels of confidence:

I. Football and Non-Athletic.

A. Reaction Time.

| | | | |
|---|---|---|---|
| 1. Simple. | -- | 1.98 | 20 per cent |
| 2. Choice. | -- | 1.56 | 20 per cent |
| 3. Discriminatory. | -- | 1.04 | Not Significant |

B. Visual Span of Apprehension. -- .80 Not Significant

C. Depth Perception. -- .82 Not Significant

II. Backs and Linemen.

A. Reaction Time.

| | | | |
|---|---|---|---|
| 1. Simple. | -- | 3.57 | 1 per cent * |
| 2. Choice. | -- | .77 | Not Significant |
| 3. Discriminatory. | -- | 1.25 | Not Significant |

B. Visual Span of Apprehension. -- .26 Not Significant

C. Depth Perception. -- 1.46 20 per cent

*In 99 out of 100 cases the two groups tested would differ in the trait measured.

# CHAPTER V

## SUMMARY AND CONCLUSIONS

Summary.-- The study was undertaken to discover what relationship existed between the reaction time, visual span of apprehension and depth perception of a football group and a non-athletic group.

Also, to find out what relationship existed between the backfield men and the linemen in these same innate capacities.

Each of the forty-four boys tested personally by the writer used the machines in the laboratory at Boston University's Department of Physical Education.

From the test results the relationships were set up in terms of the level of significance and the level of confidence established.

The two questions which the writer attempted to answer were:

1. Do football players and non-athletes differ in these innate capacities?

2. Do the backfield men differ from the linemen in these innate capacities?

Observation.-- There are many observations that can be made in view of the findings of this study. The performance of many of these boys in certain positions and certain playing reactions would seem to bear out the significance of the test results.

In the "T" formation a quarterback passer should have quick reaction, good visual span and accurate depth perception to enable him to ball-handle well, move quickly when trapped, select his receivers and judge distance. Peripheral vision would seem to be another capacity involved.

"T" halfbacks must react quickly to be effective in fast starting for quick openers, utilize visual span and depth perception in selecting courses and knowing when to break and cut.

The center in football should have reaction at least equal to or faster than any team member to prevent offsides and backs in motion.

Defensive linemen, particularly tackles, who fail to react quickly subject themselves to traps and cross blocks.

Pass defenders must necessarily be fast in reaction and have good visual span to cope with faking receivers and zone loading situations.

The extent or degree a coach may feel is the required level or measure of the innate capacities for good performance in a position or in a specific playing reaction would depend upon the requirements of the system used.

In an appraisal of the performance of some of the individuals as related to their relative standing to other linemen or backs in the test results and their accomplishments in the 1949 and 1950 seasons, certain factors stand out as being significant. The tests were given to the football lettermen after the conclusion of the 1950 season. It would appear that if the tests had been given before the season and selections made on the basis of the findings, a more accurate prediction of performance could have been made.

Numbers 21 and 4 were selected by a poll of opponents and coaches as the outstanding running backs in Eastern Massachusetts. Number 21 was selected on the All-American Schoolboy team. Both boys broke the 25-year old school scoring record, and number 4 was the highest scorer in Class "A" football in 1951. These two boys were the fastest in simple reaction time of all forty-four tested and the highest in visual span of the backs tested. Number 6 scored lowest of all forty-four tested in visual span. In pre-season passing drills his performance was excellent. He passed accurately and for distance. By subjective appraisal he appeared to have all the required ability for good performance as a "T" quarterback. However, when he was inserted at that position when the regular quarterback was injured, his performance was ihadequate. He could not find his receivers in the middle crowded area and as a result threw the ball into space or held the ball too long. This happened each game and eventually he was changed to another position.

Number 7 had the next lowest score of the forty-four boys tested in visual span. In pre-season sprint trials he was one of the fastest boys on the squad. He was ineffective as a running back and could not select lanes or react quickly enough in broken field. He was changed to an end position and did well.

Number 8 was selected by opponents and opposing coaches as Eastern Massachusetts' best high school center. This was definitely due to his linebacking ability and tackling, and tremendous spirit and attitude. However, he was weak on passes thrown quickly into his defensive zone, and he did not appear to have fast enough hand reaction to cope with these passes. We worked a great deal with our backs and linemen in the middle of the season to curb offside and back in motion penalties that we had been getting too often in the early games.

We blamed them for starting too soon. We found that they were charging on the agreed upon auditory signal, but the center was slow in getting the ball back to the quarterback. A change of position was out of the question as we had no replacement for him. We had him start the ball back a half count before the auditory signal to compensate for his slow hand reactions. Number 8 had the second slowest simple reaction time, second highest depth perception of the football group tested.

| Player Tested | Simple Reaction | Choice Reaction | Discriminatory Reaction | Visual Span | Depth Perception |
|---|---|---|---|---|---|
| | M 308 | M 455 | M 515 | M 634 | M 16.9 |
| No. 21 | 255 | 340 | 465 | 865 | 7.3 |
| 4 | 255 | 330 | 400 | 893 | 10.8 |
| 6 | 275 | 370 | 500 | 232 | 11.1 |
| 7 | 290 | 490 | 520 | 319 | 16.3 |
| 8 | 370 | 530 | 610 | 622 | 30.8 |

Conclusion.-- From this study the writer concluded the following:

1. Football players do not necessarily have faster reaction time, better visual span of apprehension or depth perception than non-athletes.
2. Backfield men are definitely faster in simple reaction time than linemen.

Table 10. Choice Reaction Time Raw Scores -- Football Group

| Case No. | Trials | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | 430 | 410 | 420 | 570 | 500 | 670 | 420 | 510 | 400 | 490 | 490 |
| 2 | 555 | 505 | 450 | 365 | 440 | 510 | 450 | 480 | 450 | 410 | 705 |
| 3 | 550 | 340 | 1000 | 510 | 480 | 525 | 330 | 420 | 450 | 320 | 490 |
| 4 | 365 | 390 | 370 | 300 | 330 | 505 | 305 | 310 | 405 | 300 | 310 |
| 5 | 600 | 545 | 630 | 555 | 410 | 430 | 460 | 495 | 570 | 450 | 455 |
| 6 | 360 | 340 | 350 | 395 | 385 | 650 | 520 | 355 | 480 | 355 | 370 |
| 7 | 545 | 535 | 475 | 430 | 400 | 520 | 470 | 540 | 500 | 490 | 345 |
| 8 | 430 | 475 | 510 | 515 | 525 | 530 | 535 | 550 | 575 | 575 | 580 |
| 9 | 460 | 490 | 525 | 510 | 405 | 600 | 395 | 360 | 380 | 455 | 490 |
| 10 | 460 | 550 | 430 | 380 | 430 | 700 | 480 | 440 | 420 | 690 | 540 |
| 11 | 550 | 450 | 450 | 380 | 385 | 430 | 405 | 325 | 340 | 320 | 455 |
| 12 | 445 | 440 | 415 | 455 | 410 | 380 | 420 | 410 | 480 | 575 | 505 |
| 13 | 375 | 420 | 490 | 415 | 500 | 435 | 390 | 440 | 415 | 565 | 465 |
| 14 | 560 | 490 | 470 | 450 | 470 | 445 | 390 | 770 | 380 | 560 | 520 |
| 15 | 420 | 385 | 335 | 525 | 535 | 445 | 390 | 460 | 490 | 365 | 370 |
| 16 | 510 | 685 | 330 | 480 | 860 | 920 | 445 | 470 | 510 | 400 | 385 |
| 17 | 580 | 590 | 365 | 460 | 385 | 635 | 525 | 375 | 535 | 415 | 585 |
| 18 | 750 | 395 | 545 | 395 | 505 | 1195 | 535 | 565 | 360 | 490 | 410 |
| 19 | 390 | 560 | 510 | 420 | 570 | 700 | 645 | 660 | 710 | 495 | 520 |
| 20 | 440 | 460 | 350 | 500 | 370 | 375 | 315 | 345 | 420 | 325 | 370 |
| 21 | 330 | 315 | 335 | 390 | 310 | 390 | 400 | 370 | 600 | 340 | 405 |
| 22 | 480 | 575 | 505 | 390 | 420 | 430 | 440 | 410 | 465 | 380 | 450 |

Table 11. Choice Reaction Time Raw Scores -- Non-Athletic Group

| Case No. | Trials | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | 450 | 560 | 405 | 540 | 920 | 500 | 520 | 405 | 535 | 510 | 490 |
| 2 | 615 | 650 | 510 | 375 | 380 | 455 | 395 | 470 | 575 | 375 | 625 |
| 3 | 410 | 360 | 580 | 440 | 415 | 445 | 385 | 335 | 330 | 410 | 600 |
| 4 | 655 | 580 | 555 | 545 | 560 | 520 | 510 | 498 | 545 | 585 | 545 |
| 5 | 465 | 350 | 480 | 370 | 550 | 580 | 380 | 400 | 500 | 350 | 535 |
| 6 | 355 | 455 | 440 | 610 | 532 | 570 | 480 | 450 | 530 | 576 | 665 |
| 7 | 520 | 530 | 685 | 510 | 590 | 460 | 695 | 465 | 510 | 595 | 370 |
| 8 | 590 | 635 | 475 | 420 | 550 | 540 | 370 | 395 | 480 | 430 | 995 |
| 9 | 380 | 445 | 455 | 470 | 490 | 500 | 590 | 625 | 630 | 660 | 690 |
| 10 | 420 | 520 | 675 | 510 | 820 | 670 | 680 | 540 | 635 | 430 | 565 |
| 11 | 450 | 440 | 535 | 420 | 480 | 560 | 480 | 480 | 560 | 450 | 380 |
| 12 | 520 | 450 | 580 | 570 | 470 | 500 | 520 | 530 | 480 | 550 | 530 |
| 13 | 470 | 590 | 440 | 560 | 500 | 380 | 550 | 420 | 615 | 430 | 420 |
| 14 | 680 | 500 | 520 | 515 | 575 | 485 | 545 | 510 | 505 | 470 | 580 |
| 15 | 480 | 480 | 410 | 340 | 400 | 390 | 510 | 400 | 550 | 360 | 400 |
| 16 | 730 | 395 | 410 | 520 | 400 | 400 | 550 | 485 | 530 | 425 | 520 |
| 17 | 430 | 425 | 495 | 490 | 500 | 560 | 660 | 420 | 415 | 515 | 520 |
| 18 | 600 | 550 | 435 | 545 | 410 | 425 | 440 | 405 | 575 | 430 | 560 |
| 19 | 375 | 420 | 490 | 565 | 425 | 500 | 415 | 420 | 565 | 435 | 440 |
| 20 | 535 | 605 | 460 | 540 | 510 | 435 | 540 | 495 | 510 | 490 | 500 |
| 21 | 620 | 360 | 350 | 370 | 340 | 395 | 340 | 360 | 350 | 385 | 490 |
| 22 | 600 | 630 | 450 | 545 | 445 | 450 | 575 | 460 | 430 | 420 | 440 |

Table 12. Discriminatory Reaction Time Raw Scores -- Football Group

| Case No. | Trials 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 450 | 490 | 505 | 565 | 505 | 635 | 500 | 595 | 515 | 380 | 510 |
| 2 | 520 | 525 | 475 | 605 | 605 | 515 | 490 | 620 | 470 | 410 | 510 |
| 3 | 440 | 375 | 500 | 555 | 615 | 520 | 970 | 520 | 385 | 555 | 425 |
| 4 | 340 | 385 | 505 | 555 | 520 | 620 | 500 | 445 | 410 | 505 | 385 |
| 5 | 560 | 535 | 575 | 745 | 690 | 540 | 660 | 415 | 455 | 590 | 525 |
| 6 | 585 | 480 | 490 | 495 | 605 | 670 | 340 | 620 | 355 | 500 | 530 |
| 7 | 780 | 580 | 950 | 440 | 590 | 620 | 925 | 700 | 890 | 420 | 555 |
| 8 | 490 | 555 | 590 | 590 | 590 | 610 | 630 | 635 | 640 | 650 | 765 |
| 9 | 405 | 505 | 615 | 480 | 590 | 675 | 435 | 475 | 495 | 590 | 720 |
| 10 | 520 | 455 | 470 | 690 | 630 | 780 | 440 | 550 | 560 | 550 | 630 |
| 11 | 450 | 390 | 390 | 900 | 320 | 600 | 360 | 550 | 330 | 340 | 440 |
| 12 | 435 | 580 | 445 | 555 | 650 | 490 | 560 | 500 | 425 | 545 | 595 |
| 13 | 405 | 480 | 555 | 620 | 580 | 495 | 585 | 590 | 360 | 570 | 480 |
| 14 | 620 | 710 | 535 | 500 | 550 | 710 | 350 | 420 | 410 | 350 | 440 |
| 15 | 460 | 315 | 525 | 575 | 485 | 730 | 390 | 470 | 495 | 440 | 690 |
| 16 | 465 | 475 | 410 | 560 | 615 | 375 | 855 | 370 | 505 | 465 | 670 |
| 17 | 595 | 425 | 470 | 525 | 720 | 455 | 605 | 610 | 450 | 445 | 345 |
| 18 | 350 | 670 | 460 | 420 | 545 | 965 | 515 | 610 | 450 | 445 | 555 |
| 19 | 560 | 580 | 700 | 810 | 610 | 610 | 460 | 660 | 520 | 595 | 505 |
| 20 | 480 | 360 | 550 | 590 | 420 | 475 | 680 | 675 | 550 | 330 | 452 |
| 21 | 410 | 540 | 450 | 360 | 465 | 760 | 660 | 350 | 375 | 570 | 630 |
| 22 | 630 | 600 | 920 | 460 | 430 | 490 | 435 | 765 | 480 | 470 | 480 |

Table 13. Discriminatory Reaction Time Raw Scores -- Non-Athletic Group

| Case No. | Trials | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | 445 | 690 | 465 | 560 | 720 | 550 | 740 | 480 | 405 | 520 | 520 |
| 2 | 490 | 470 | 410 | 1000 | 630 | 790 | 320 | 510 | 920 | 490 | 430 |
| 3 | 320 | 350 | 475 | 610 | 420 | 320 | 710 | 570 | 760 | 575 | 550 |
| 4 | 580 | 680 | 550 | 540 | 560 | 710 | 505 | 590 | 481 | 470 | 545 |
| 5 | 380 | 490 | 580 | 450 | 515 | 490 | 350 | 480 | 400 | 340 | 345 |
| 6 | 540 | 415 | 735 | 405 | 630 | 355 | 490 | 420 | 435 | 380 | 505 |
| 7 | 400 | 370 | 365 | 565 | 570 | 325 | 445 | 595 | 485 | 520 | 305 |
| 8 | 560 | 490 | 445 | 415 | 595 | 625 | 630 | 855 | 430 | 455 | 535 |
| 9 | 440 | 450 | 500 | 500 | 500 | 615 | 625 | 675 | 690 | 690 | 695 |
| 10 | 650 | 690 | 570 | 640 | 540 | 625 | 530 | 520 | 550 | 560 | 590 |
| 11 | 355 | 550 | 605 | 560 | 555 | 680 | 500 | 470 | 580 | 420 | 560 |
| 12 | 500 | 750 | 560 | 490 | 490 | 850 | 520 | 650 | 480 | 595 | 590 |
| 13 | 470 | 495 | 415 | 660 | 595 | 670 | 595 | 600 | 595 | 640 | 600 |
| 14 | 605 | 650 | 705 | 650 | 750 | 895 | 495 | 580 | 540 | 480 | 800 |
| 15 | 375 | 450 | 400 | 540 | 545 | 670 | 400 | 630 | 410 | 350 | 570 |
| 16 | 610 | 480 | 510 | 655 | 545 | 485 | 460 | 560 | 620 | 380 | 485 |
| 17 | 600 | 770 | 510 | 880 | 700 | 915 | 435 | 555 | 440 | 580 | 630 |
| 18 | 505 | 385 | 410 | 445 | 375 | 660 | 520 | 495 | 555 | 520 | 410 |
| 19 | 465 | 390 | 390 | 320 | 880 | 900 | 600 | 535 | 330 | 355 | 550 |
| 20 | 520 | 660 | 575 | 635 | 440 | 690 | 465 | 620 | 490 | 560 | 630 |
| 21 | 450 | 660 | 330 | 340 | 430 | 550 | 600 | 390 | 380 | 775 | 390 |
| 22 | 850 | 570 | 460 | 520 | 460 | 490 | 565 | 380 | 535 | 540 | 500 |

Table 14. Visual Span of Apprehension Scores -- Football

| Case No. | Stimulus 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 76 | 90 | 96 | 21 | 96 | 18 | 140 | 0 | 60 | 0 | 597 |
| 2 | 76 | 95 | 102 | 98 | 80 | 72 | 50 | 66 | 60 | 52 | 751 |
| 3 | 72 | 65 | 84 | 63 | 48 | 18 | 60 | 11 | 72 | 65 | 558 |
| 4 | 80 | 80 | 102 | 112 | 136 | 117 | 90 | 77 | 60 | 39 | 893 |
| 5 | 80 | 75 | 78 | 63 | 32 | 36 | 20 | 33 | 24 | 65 | 506 |
| 6 | 56 | 35 | 30 | 35 | 8 | 45 | 0 | 11 | 12 | 0 | 232 |
| 7 | 80 | 65 | 72 | 63 | 40 | 27 | 40 | 0 | 12 | 0 | 319 |
| 8 | 60 | 65 | 90 | 56 | 56 | 72 | 80 | 33 | 84 | 26 | 622 |
| 9 | 80 | 90 | 96 | 70 | 72 | 45 | 30 | 55 | 72 | 52 | 662 |
| 10 | 68 | 85 | 102 | 56 | 48 | 27 | 50 | 44 | 60 | 65 | 605 |
| 11 | 80 | 85 | 84 | 56 | 40 | 63 | 50 | 22 | 180 | 13 | 673 |
| 12 | 68 | 90 | 102 | 84 | 80 | 18 | 60 | 33 | 60 | 39 | 634 |
| 13 | 48 | 75 | 54 | 28 | 0 | 0 | 30 | 22 | 84 | 52 | 393 |
| 14 | 52 | 26 | 143 | 70 | 63 | 40 | 70 | 90 | 85 | 64 | 703 |
| 15 | 72 | 100 | 96 | 84 | 88 | 54 | 100 | 77 | 72 | 26 | 769 |
| 16 | 80 | 85 | 102 | 63 | 80 | 81 | 80 | 44 | 24 | 52 | 691 |
| 17 | 80 | 85 | 120 | 126 | 80 | 126 | 90 | 88 | 96 | 65 | 956 |
| 18 | 80 | 85 | 96 | 91 | 80 | 54 | 20 | 22 | 12 | 26 | 566 |
| 19 | 80 | 95 | 108 | 105 | 96 | 81 | 110 | 44 | 36 | 13 | 768 |
| 20 | 56 | 65 | 84 | 42 | 72 | 72 | 110 | 44 | 96 | 26 | 667 |
| 21 | 92 | 95 | 108 | 119 | 120 | 108 | 70 | 55 | 72 | 26 | 865 |
| 22 | 80 | 80 | 108 | 77 | 56 | 36 | 40 | 33 | 48 | 52 | 610 |

Table 15. Visual Span of Apprehension Scores -- Non-Athletic Group

| Case No. | Stimulus 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 68 | 80 | 60 | 77 | 80 | 18 | 70 | 0 | 0 | 0 | 453 |
| 2 | 72 | 95 | 90 | 98 | 48 | 45 | 70 | 22 | 48 | 39 | 627 |
| 3 | 76 | 85 | 84 | 98 | 88 | 90 | 100 | 44 | 60 | 65 | 790 |
| 4 | 72 | 75 | 84 | 70 | 72 | 18 | 60 | 22 | 48 | 13 | 534 |
| 5 | 80 | 90 | 108 | 105 | 72 | 63 | 50 | 11 | 48 | 0 | 627 |
| 6 | 76 | 90 | 102 | 77 | 56 | 63 | 80 | 33 | 72 | 13 | 662 |
| 7 | 76 | 80 | 96 | 91 | 48 | 63 | 60 | 33 | 36 | 26 | 609 |
| 8 | 68 | 75 | 108 | 84 | 104 | 63 | 40 | 22 | 72 | 39 | 675 |
| 9 | 80 | 100 | 114 | 28 | 96 | 153 | 100 | 66 | 48 | 65 | 850 |
| 10 | 80 | 85 | 90 | 56 | 88 | 27 | 90 | 22 | 72 | 0 | 610 |
| 11 | 60 | 60 | 60 | 70 | 64 | 54 | 70 | 22 | 36 | 13 | 509 |
| 12 | 76 | 65 | 42 | 35 | 32 | 0 | 0 | 11 | 48 | 52 | 361 |
| 13 | 72 | 70 | 60 | 49 | 32 | 27 | 40 | 77 | 60 | 52 | 539 |
| 14 | 92 | 70 | 96 | 77 | 56 | 54 | 0 | 33 | 36 | 13 | 527 |
| 15 | 60 | 85 | 84 | 21 | 48 | 18 | 10 | 11 | 12 | 26 | 375 |
| 16 | 76 | 80 | 96 | 70 | 48 | 45 | 60 | 11 | 48 | 26 | 560 |
| 17 | 60 | 80 | 114 | 35 | 112 | 81 | 50 | 33 | 80 | 65 | 710 |
| 18 | 84 | 95 | 102 | 63 | 80 | 90 | 70 | 22 | 60 | 0 | 666 |
| 19 | 52 | 70 | 72 | 56 | 64 | 54 | 50 | 22 | 36 | 13 | 489 |
| 20 | 92 | 100 | 84 | 91 | 56 | 72 | 100 | 55 | 72 | 52 | 774 |
| 21 | 76 | 90 | 90 | 56 | 96 | 18 | 80 | 33 | 60 | 13 | 612 |
| 22 | 84 | 100 | 102 | 112 | 72 | 54 | 50 | 22 | 12 | 26 | 634 |

Table 16. Depth Perception Readings and Scores -- Football

| Case No. | Trials 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10 | 25 | 24 | 22 | 19 | 25 | 10 | 16 | 15 | 29 | 20.5 |
| 2 | 32 | 15 | 15 | 10 | 30 | 14 | 24 | 9 | 18 | 10 | 19.4 |
| 3 | 2 | 19 | 8 | 1 | 1 | 15 | 44 | 2 | 3 | 30 | 18.7 |
| 4 | 8 | 4 | 12 | 9 | 11 | 8 | 24 | 4 | 1 | 9 | 10.8 |
| 5 | 10 | 12 | 15 | 6 | 2 | 5 | 11 | 15 | 8 | 18 | 11.3 |
| 6 | 14 | 13 | 11 | 6 | 4 | 20 | 5 | 16 | 10 | 8 | 11.1 |
| 7 | 15 | 4 | 16 | 15 | 8 | 6 | 32 | 22 | 14 | 11 | 16.3 |
| 8 | 3 | 13 | 14 | 23 | 25 | 29 | 35 | 40 | 40 | 52 | 30.8 |
| 9 | 41 | 5 | 4 | 32 | 5 | 16 | 6 | 36 | 56 | 2 | 27.4 |
| 10 | 6 | 14 | 11 | 6 | 32 | 3 | 6 | 17 | 9 | 22 | 15.2 |
| 11 | 5 | 8 | 14 | 3 | 6 | 3 | 1 | 2 | 0 | 2 | 5.9 |
| 12 | 65 | 21 | 2 | 15 | 20 | 4 | 25 | 24 | 75 | 5 | 34.9 |
| 13 | 1 | 11 | 30 | 22 | 31 | 58 | 2 | 3 | 1 | 5 | 24.2 |
| 14 | 3 | 6 | 0 | 5 | 5 | 4 | 9 | 2 | 6 | 9 | 5.6 |
| 15 | 9 | 10 | 2 | 3 | 12 | 0 | 4 | 3 | 6 | 2 | 6.3 |
| 16 | 3 | 9 | 11 | 19 | 5 | 11 | 6 | 9 | 15 | 20 | 12.1 |
| 17 | 50 | 17 | 24 | 12 | 4 | 12 | 34 | 5 | 11 | 15 | 22.8 |
| 18 | 25 | 0 | 14 | 8 | 39 | 1 | 4 | 6 | 5 | 0 | 15.8 |
| 19 | 24 | 28 | 43 | 46 | 26 | 26 | 16 | 24 | 9 | 44 | 30.9 |
| 20 | 5 | 1 | 4 | 10 | 23 | 20 | 11 | 1 | 2 | 14 | 11.4 |
| 21 | 7 | 9 | 7 | 12 | 4 | 0 | 8 | 9 | 6 | 4 | 7.3 |
| 22 | 12 | 22 | 8 | 7 | 9 | 9 | 24 | 7 | 14 | 6 | 13.3 |

Table 17. Depth Perception Readings and Scores -- Non-Athletic

| Case No. | Trials 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 | 3 | 14 | 25 | 2 | 16 | 40 | 18 | 6 | 27 | 20.9 |
| 2 | 18 | 9 | 20 | 5 | 5 | 15 | 4 | 10 | 12 | 6 | 11.7 |
| 3 | 102 | 11 | 59 | 15 | 68 | 110 | 38 | 49 | 34 | 65 | 63.4 |
| 4 | 59 | 33 | 52 | 65 | 4 | 66 | 54 | 17 | 47 | 41 | 44.5 |
| 5 | 9 | 10 | 0 | 1 | 24 | 3 | 4 | 1 | 3 | 5 | 9.0 |
| 6 | 36 | 9 | 20 | 14 | 29 | 17 | 22 | 22 | 25 | 21 | 22.7 |
| 7 | 11 | 22 | 5 | 7 | 11 | 6 | 0 | 0 | 6 | 10 | 10.4 |
| 8 | 15 | 28 | 21 | 71 | 75 | 31 | 39 | 11 | 43 | 12 | 42.1 |
| 9 | 5 | 6 | 6 | 10 | 15 | 15 | 18 | 18 | 21 | 25 | 15.4 |
| 10 | 20 | 9 | 22 | 24 | 23 | 24 | 1 | 16 | 13 | 29 | 19.8 |
| 11 | 27 | 37 | 16 | 7 | 66 | 0 | 3 | 27 | 12 | 4 | 27.7 |
| 12 | 0 | 4 | 14 | 5 | 44 | 15 | 6 | 40 | 43 | 0 | 24.3 |
| 13 | 22 | 23 | 11 | 20 | 19 | 15 | 4 | 9 | 7 | 3 | 15.1 |
| 14 | 29 | 64 | 9 | 1 | 15 | 13 | 9 | 0 | 71 | 7 | 32.6 |
| 15 | 23 | 23 | 7 | 10 | 19 | 11 | 2 | 16 | 11 | 9 | 14.3 |
| 16 | 18 | 6 | 10 | 19 | 2 | 9 | 28 | 23 | 15 | 33 | 18.2 |
| 17 | 7 | 12 | 18 | 16 | 7 | 0 | 4 | 11 | 20 | 6 | 11.8 |
| 18 | 7 | 2 | 11 | 9 | 4 | 10 | 1 | 13 | 16 | 0 | 8.9 |
| 19 | 33 | 19 | 26 | 6 | 17 | 23 | 45 | 14 | 19 | 43 | 27.2 |
| 20 | 6 | 0 | 3 | 9 | 0 | 1 | 15 | 3 | 8 | 11 | 7.4 |
| 21 | 3 | 0 | 21 | 5 | 1 | 0 | 3 | 9 | 19 | 6 | 9.8 |
| 22 | 14 | 2 | 9 | 15 | 6 | 3 | 12 | 8 | 3 | 9 | 9.2 |

Table 18. Sample for Recording Data (On 4x6 White Card)

Name________________________ Age____________ Sex____________

Height_____ Weight_____ School________________ Age____________

Athletic background:

High school

Varsity sports____________________________________

Junior varsity sports______________________________

Others___________________________________________

Hobby________________________________________________

(On Other Side)

| | Reaction Time | | | Depth | Visual Span of Apprehension | | |
|---|---|---|---|---|---|---|---|
| | Simple | Choice | Discriminatory | Perception | Stimulus | #Slides Correct | Score |
| 1 | 310 | 440 | 360 | 4.5 | 4 | 14 | 56 |
| 2 | 330 | 460 | 550 | 1. | 5 | 13 | 65 |
| 3 | 345 | 350 | 590 | 4. | 6 | 14 | 84 |
| 4 | 295 | 500 | 420 | 10. | 7 | 6 | 42 |
| 5 | 270 | 370 | 475 | 23. | 8 | 9 | 72 |
| 6 | 295 | 370 | 680 | 20. | 9 | 8 | 72 |
| 7 | 280 | 375 | 675 | 11. | 10 | 11 | 110 |
| 8 | 280 | 315 | 550 | 1. | 11 | 4 | 44 |
| 9 | 220 | 345 | 330 | 2. | 12 | 8 | 96 |
| 10 | 260 | 420 | 452 | 14. | 13 | 2 | 26 |
| 11 | 260 | 325 | | | 14 | 0 | 0 |
| | | | | | | Total | 667 |

Table 19. Length of Fore-period and Order of Presentation of Stimuli for Reaction Time Tests

Simple Reaction Time

| Trial | 1 | 2 | 3 | 4 | 5 | 6. | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fore-period in seconds | 2 | 4 | 2 | 3 | 2 | 3 | 4 | 3 | 2 | 3 | 4 |

Choice Reaction Time

| Trial | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fore-period in seconds | 3 | 4 | 3 | 4 | 4 | 4 | 3 | 2 | 2 | 2 | 2 |
| Stimulus* | A | A | G | A | G | G | A | G | G | A | G |

Discriminatory Reaction Time

| Trial | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fore-period in seconds | 4 | 4 | 4 | 2 | 4 | 3 | 4 | 2 | 2 | 2 | 3 |
| Stimulus* | R | G | A | G | A | A | R | A | G | R | G |

*A - Amber G - Green R - Red

# BIBLIOGRAPHY


1. Armstrong, Harry G., Principles and Practices of Aviation Medicine. Williams and Wilkins Company, Baltimore, 1943.

2. Atweel, W. O., and E. R. Elbel, "Reaction Time in Male High School Students in 14-17 Age Group", Research Quarterly. Volume 19, March, 1948.

3. Baird, J. W., "The Influence of Accommodations and Convergence Upon the Perception of Depth Perception", American Journal of Psychology. January, 1903.

4. Beise, Dorothy and Virginia Peasely, "The Relation of Reaction Time Speed, Agility of Big Muscle Groups to Certain Sport Skills", Research Quarterly. Volume 3, March, 1937.

5. Berens, Conrad and Joshua Zuckerman, Diagnostic Examination of the Eyes. Lippnosti Publishers, 1946.

6. Bills, A. G., General Experimental Psychology. Longmons, Green and Company, New York, 1934.

7. Burley, L. R., "Study in Reaction Time of Physically Trained Men", Research Quarterly. Volume 8, March, 1936.

8. Burpee, Royal H., and Wellington Stroll, "Measuring Reaction Time of Athletes", Research Quarterly. Volume 8, March, 1936.

9. Cottell, J. M., and Charles S. Dolley, "On Reaction Times and Velocity of the Nervous Impulse", Memoirs of National Academy of Sciences. Volume VII, Government Printing Office, Washington, D. C., 1895.

10. Eames, T. H., "Study of Speed Word Recognition", Journal of Educational Research. 1937.

11. Elbel, E. R., "Study in Variation in Response Time", Research Quarterly. Volume 10, March, 1939.

12. Fernberger, S. W., "Study of the Range of Visual Apprehension", American Journal of Psychology. Volume 32, 1921.

13. Fernberger, S. W., "A Preliminary Study of the Range of Visual Apprehension", American Journal of Psychology. 39:121-123, 1921.

14. Goldfarb, W., Ph.D., "An Investigation of Reaction Time in Older Adults", Bureau of Publications. Teachers College, Columbia University, New York, 1941.

15. Henmon, V. A. C., "Professor Cottell's Work on Reaction Time", Archives of Psychology. Number 30, 1914.

16. Keller, Louis F., "The Relation of Quickness of Bodily Movement to Success in Athletics", Research Quarterly. Volume 13, May, 1942.

17. Kiilpe, Oswald, Outlines of Psychology, Swan Sonnenscheim and Company, London, MacMillan and Company, New York, 1945, pp. 357-361.

18. Knehr, C. A., "The Effects of Monocular Vision on Measures of Reading Efficiency and Perceptual Span", Journal of Experimental Psychology. 29:133-154, 1941.

19. Loy, A. W., "The Value of Peripheral Vision in Depth Perception as Applied to Aviation", Naval Medical Bulletin. Volume 28, 1930, pp. 13-18.

20. McCloy, C. H., Tests and Measurements in Health and Physical Education. Appleton-Century-Crofts, Inc., New York.

21. Miles, W. R., and B. C. Graves, "Effect of Signal Variation on Football Charging", Research Quarterly. Volume 2, October, 1931, pp. 1-5.

22. Miles, W. R., "Individual and Group Reaction Time in Football Charging", Research Quarterly, Volume 2, Number III, October, 1931.

23. Millis, A. E., "Depth Perception as an Aid to Selecting Fighter Pilots", Journal of Aviation Medicine. Volume 15, 1944, pp. 328-329.

24. Rockne, K., Coaching. The Devin-Adair Company, New York, 1925, pp. 168-169.

25. Saltzman, J., and W. R. Garner, "Reaction Time as a Measure of Span of Attention", Journal of Psychology, 25:227-241, 1948.

26. Scott, R. B., and F. C. Sumner, "Eyedness as Affecting Results Obtained with the Howard-Dolman Apparatus", Journal of Psychology. Volume 27, April, 1949, pp. 29-30.

27. Slater-Hammel, A. T. and R. L. Stumpner, "Choice Batting Reaction-Time", Research Quarterly. Volume 22, October, 1951.

28. Symonds, P. M., Diagnosing Personality and Conduct. p. 111. 1931.

29. Wells, F. L., "Statistical Study of Literary Merit", Archives of Psychology. Number 7, 1907, p. 21.

30. Weymouth, F., and M. Hirsch, "Reliability of Certain Tests for Determining Distance Discrimination", American Journal of Psychology. 1945.

31. Whipple, G. M., "The Effect of Practice Upon the Range of Visual Apprehension", Journal of Educational Psychology. May, 1910, pp. 249-262.

32. Woodworth, Robert S., Experimental Psychology. H. Holt and Company, New York, 1938.